

Revised Anatomy of Stars

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Abstract: Stars including the Sun, continuously accrete near invisible hydrogen dominated agglomerates. This weakly bound ubiquitous baryonic population, ‘dark matter,’ known by its gravitational influence on stellar and galactic motion, profoundly effects the formation, function and evolution of stars. Measurements, many requiring recent space borne instrumentation, provide ample evidence that plasma streams of ions, microparticles and macromolecules resulting from the disruption of these clusters impact Earth, the planets, the Sun and stars. This sizable mass-energy source contradicts a fundamental assumption of the generally accepted nebula collapse model of stellar formation. The visually derived textbook model, to which later discoveries (e.g., fusion) were appended, is increasingly confounded and contradicted by new observations. The discovery of a sizable quantity of radioactive ^7Be (53 day half-life) in the Earth’s upper atmosphere with later tests showing it fusion produced, hence coming from the solar outer zone, proves the stellar core fusion theory wrong. Magnetically pinched plasma vortices, derived from continuing sporadic capture of hydrogen dominated aggregates, impact stars at hundreds of kilometers per second, create impulsive local conditions that initiate finite nuclear fusion explosions below the photosphere. Integral to the aggregate capture process are disks with imbedded planets that belt stars. Giant planets in particular, modulate the cluster influx resulting in short term variable fusion rates, hence luminosity (e.g., solar cycle). Recognition of continuing accretion of this population, with no assumptions or ad hoc physics, explains many stellar phenomena heretofore mysterious, e.g., luminosity/wind variation, sunspots, sporadic radial magnetic fields, differential rotation, high temperature corona, flares, CMEs, etc. Accepted model phenomenologic explanations (where existent) are compared with derivations from continuing stellar accretion, e.g., tortuous H-R stellar evolution tracks with unobservable (helium flash) kinks contrasted with growth along the main sequence curve.

Key words: accretion, accretion disks - nuclear reactions, nucleosynthesis, abundances - sun: activity - stars: evolution - stars: formation - dark matter

Preamble

If you believe astrophysics, as presently taught is a valid depiction of the nature of stars, despite ignorance of the physical form of $> 90\%$ of universal mass; the tacit assumption that this dominant mass form's only manifestation is in the orbits of stars and galaxies; the continuing series of minor theory modifications will someday explain newly observed phenomena that puzzle and confound; then we suggest you stop reading here. No argument, even one resting upon a firm foundation of observation will change your opinion. If, however, you are troubled by the many inconsistencies and inexplicables introduced by recent observations and believe that a fundamental change in the way we think about stars is overdue, then open your mind and proceed.

1. Opening

Anatomy by definition is associated with biological systems. We used the term in the title to point up the similarity between this new view of stars and highly evolved biological entities. Generally accepted stellar theory was built upon astronomic observation. Modifications for subsequent detection of unseen mass and radiation were appended to hypotheses derived from visual and photographic records. The theory worked, after a fashion, explaining most observations (with assumptions added as required), so it persisted, despite growing evidence of fundamental flaws. Hypothetically, stars were formed from nebulae collapse because the gravitational potential energy was needed to explain the luminosity before fusion was recognized. Fusion was inserted in the core over half a century ago after recognition that gravitational energy was insufficient for stellar lifetimes. Today, space borne instruments measuring radiation in portions of the spectrum unavailable to earlier observers and particle detectors unimagined until recently are routinely finding information incompatible with or inexplicable by the paradigm. Although we recognize the multitude of nuances and variations; in what follows, we combine all into what we call the standard stellar model (SSM) as described in current textbooks (e.g., Kippenhahn & Weigert 1994). SSM is also widely used as the abbreviation for the standard solar model (e.g., Bahcall & Pinsonneault 1992). As this is a subset of the standard stellar model we will use SSM to refer to both. It should be clear when we refer to the Sun; which we treat as a typical star.

When a structure increasingly displays cracks, openings and displacements upon each new examination, it is frequently the foundation at fault. Examples of the many problems with SSM include short period luminosity variations, stellar winds that render large stars volatile in comparatively short times, multitudes of non thermal surface phenomena, e.g., spots, flares, plumes, CMEs, high energy radiation, etc. For a scientific model, the foundation is oft built upon assumptions or theorems. SSM rests upon one stated by Russell (Russell et al. 1927) and Vogt (1926) that a star's nature and evolution is determined at its birth by a fixed mass and chemical composition. Nebula collapse is thus interpreted as a brief (relative to the stellar lifetime) initiating occurrence. We shall show by citing numerous observations that this assumption is wrong; i.e., stellar mass accretion is a continuing process. Significant increasing mass over time necessitates major alterations to the accepted model of planetary and stellar behavior. To contrast SSM with continuing accretion (SAM for stellar accretion model), we briefly summarize both.

1.1 Standard Stellar Model (SSM) Summary

A gaseous interstellar nebula, generated by a supernova is cooled and compressed (mechanism uncertain) past criticality causing rapid gravitational collapse.

Planets, moons, comets and asteroids, condensed remnants of the original nebula, orbit the central star(s), angular momentum conserved (collisions required to modify consistency).

Dust from the nebula, comets and collisions (insufficient sources!) form short lived rings and spiral slowly into the star due to relativistic (Poynting - Robertson) drag.

Nebula potential energy thermalized in the central star(s) initiates fusion in the core(s). No mechanism known for wind or instabilities.

In contrast to the foregoing we summarize the continuing stellar accretion model (SAM) briefly. Evidence for and consequences of SAM are expanded subsequently.

1.2 Continuing Stellar Accretion (SAM) Summary

Cold, weakly bound, largely molecular hydrogen aggregates are gravitationally drawn near stars where some are trapped to form an orbiting disk. Sublimation, jetting plus disruption enhance the small particle end of the size distribution.

Interaction with the disk traps more agglomerates. Some are directed by gravitation and radiation to impact the central star(s) with escape velocity. Aggregates orbiting in the disk continuously grow by accreting some of the infalling mass.

Large masses (planets) within the disk form their own smaller disks within which satellites may form or be captured (no need for angular momentum consistency).

Aggregate derived hydrogen plasmas enter the stellar atmosphere with velocities and forces sufficient to fuse, providing mass and energy for radiation and wind.

Stellar wind and radiation interact with infalling agglomerates building more complex nuclei, atoms and molecules.

1.3 Observation derived themes

In revising stellar anatomy, we develop four observation derived themes. Beginning with continuing accretion and evidence thereof, we next discuss the effect of continuing accretion upon the nature of stars, with emphasis upon the fusion process. Third we present experimental proof that for the Sun, a typical star whose proximity allows greater knowledge, SSM is wrong and only SAM can explain recent measurements. Fourth we develop the case against SSM and for SAM.

2. Continuing Stellar Accretion (SAM)

Stars will accrete matter gravitationally if it penetrates their radiation pressure and stellar wind barrier. Clustered or agglomerated matter with small area to mass ratio

gets through. Intergalactic velocities (Zwicky 1937) and galactic rotation (Rubin et al. 1980) demonstrate that abundant mass exists for continuing stellar accretion.

In cold, field free, intergalactic space, hydrogen with some helium plus trace constituents weakly bond by contact forces. Collision energy is radiated. The absence of appreciable intergalactic electromagnetic absorption by mass that exerts its gravitational influence implies large scale clustering. Interstellar space is cold. Eddington (1926) calculated that, with only the energy of stars to warm them, the radiative equilibrium temperature of diffuse interstellar matter is about 3.18 K. This is observationally confirmed by the cyanogen molecule (CN) that provides a near 3 K interstellar space thermometer. The relative populations of the ground and first excited states as calculated from the absorption spectrum provides a means of determining the molecular temperature. As it is improbable that the molecule could be collisionally excited between stars, the relative excitation temperature of 2.3 K ($\lambda = 2.6$ mm) requires a pervasive millimeter radiation environment to explain the measurements. The presence of interstellar CN, a molecule routinely measured in comet spectra, further supports cluster/agglomerate existence in and near the galaxy. That it is observed in interstellar rather than intergalactic space is in keeping with limited dispersion from the population in the comparatively radiation and particulate cluttered galaxy.

Stellar capture of these weak hydrogen dominated clusters is a multibody interactive process. In gravitational swingby, a few will be dispersed by stellar flare and wind encounter, going into eccentric stellar orbit. Poynting - Robertson radiation and wind interaction gradually circularize and equatorialize the orbits producing a stellar disk. The disk, extending outward more than a light year abets further agglomerate capture. Infrared and submillimeter observations show that at least half the nearby stars are surrounded by disks of gas and dust that must be continuously supplied (Sargent & Beckwith 1993). At the outer limits ($R_{\text{disk}} \sim .3$ pc), where the stellar radiation is too weak to sublimate the hydrogen, the clusters continue to grow by stellar augmented accretion. The disk perturbs some of the passing aggregates and directs them toward the star. The interaction provides an angular momentum bias commensurate with the disk's rotation about the central star. Only those in the far zone (outside the hydrogen sublimation range) grow to comet size. Occasionally, a kilometer or larger sized aggregate is perturbed into short period orbit. On entering the central zone they display random orbits reflecting small perturbations of initially large periastron radii. As with all astronomical distributions, the several order of magnitude larger comets are comparatively few in number. More frequently, passing multimeter and smaller agglomerates plus perturbed orbiters will be directed toward the star. Recent ultraviolet observations with the Goddard High-Resolution Spectrograph on the Hubble Space Telescope evidence such bodies within the disk about Beta Pictoris falling toward the star at several hundred kilometer per second velocities (Lagrange et al. 1996).

Radiation and wind interaction, particularly at times of sudden onset, produce structural stresses that cause jetting, evaporation and complete dispersion of agglomerates. The separated volatile dust and gas form anti-stellar tails. Freed from the agglomerate these tail constituents succumb to radiation pressure, slow and if far from

the star, reverse direction to join the wind. Material jetted and volatilized within several stellar radii retain sufficient momentum to impact the photosphere with less than escape velocity. Remnants of the original cluster (considerably reduced in size and mass), dust, plasma, atoms and molecules impacting at hypervelocity constitute a continuing supply of hyperthermal energy.

The disk is an extension of the star's gravitational reach that improves cluster capture. The enhanced capture increases the size and density of the disk with age, i.e., symbiosis. It is important to clarify a key point before proceeding. Readers familiar with studies of stellar disks will question our statement of continuing growth. It must be kept in mind, however, that continuing stellar accretion means that stars grow. Consequently, assumptions of stellar age (founded upon a finite fuel supply) are reversed. To avoid confusion in the minds of most readers familiar with the counterintuitive model of bright massive blue stars being newborns, whenever we touch upon stellar age we shall qualify young with low mass red or infra-red and old with massive bright blue adjectives. Thus the presence of highly developed disks about bright blue stars and absence about dim red stars is consistent with both SSM and SAM. Detections of disks about main sequence solar type stars such as β Pictoris, however, poses a SSM dilemma as such disks have theorized lives of fractional millions of years after nebula collapse.

Gravitation and drag within the disk cause agglomerates to be directed toward the central body. Within several AU, central radiation guides meter (and smaller) sized clusters. Sublimation produces a 'non-gravitational force' (observed with comets) that directs the cluster to the radiating source.

Continuing accretion is widely accepted on binary stars. The mass is hypothesized to originate from the larger star beyond its Roche limit. How this can penetrate the smaller star's radiation barrier is rarely, if ever discussed. Agglomerates feed both members of binaries. The interactive path causes dispersion, producing a luminous wind between the pair. Changing orientation of this interactive path relative to the dominant cluster influx direction produces orbital period luminosity and wind modulation. The identification of a candidate disk about the binary BD+31°643 (Kalas & Jewitt 1997) show both members accreting mass. A commentary (Lissauer 1997) points out the SSM discrepancy if confirmed.

Stellar winds are common to all stars. The larger the influx and luminosity, the greater will be the stellar wind. The anomaly of luminous O and B stars evaporating in relatively short times (Thomas 1993) vanishes. The feedback between the wind and the continuing influx is complex. Only a few aspects are treated below.

Larger bodies with appreciable gravitational contraction are occasionally trapped or, in the enhanced accretion environment, grow within the disk. At the extreme, these form planets that may orbit relatively close, some gravitationally retaining hydrogen and helium. The planets continue to accrete a portion of the incoming flux and gravitationally direct part to the central star. Because of the disk rotation bias, the planets will, in time, develop commensurate near circular orbits in the equatorial plane of the star. In contrast to the nebula collapse hypothesis, the rotational and orbital angular momentum of the planets need not conform to that of the star and

disk.

The nebular collapse angular momentum problem has vexed SSM theorists for many years. Like a skater bringing outstretched arms inward, the central star in a collapsing nebula should spin rapidly. That few stars exhibit high spin rates raises the question of what becomes of the angular momentum. Complex magnetohydrodynamic hypotheses are invoked to link the disk to jets that erupt from T Tauri stars to explain the missing SSM angular momentum (Ouyed et al. 1997; Ray et al. 1997).

The physics of continuing accretion on a lesser scale, produces rings, moons and disks about massive planets. Inner moons and rings (disks) will be equatorial and conform to the angular momentum of the planet. Outer moons, likely captured more recently, may orbit and spin different from inner bodies.

Unlike SSM where disks, planets and moons are remnants of nebula collapse (despite a physical demand for continuous disk supply), serving no purpose in the stellar function, continuing accretion promotes the existence of planets about mature stars. Subsequent, we describe how many stellar luminosity cycles evidence the presence of orbiting planets. The disk with imbedded planets extends the gravitational reach of stars increasing cluster influx. Once inside the disk, planets help direct a fraction of the trapped population to the star. This is seen in the influence of Jupiter changing long to short period comets.

Accretion increases the mass of the planets and produces lesser disks about them. As on the stellar scale, SAM poses no requirement for consistent angular momentum, a major SSM dilemma. Continuing growth causes one planet to eventually become a companion binary star. In the next section we treat the onset of fusion that initiates stellar status, showing how this occurs during continuing accretion. Planetary accretion rates vary not only with gravity but also the electromagnetic environment, producing differing growth, disk, ring and moon structure. Thus, a binary need not evolve from the largest planet.

As the mass of the star(s) and satellites increase, so too may their separation. In time, planets drift away from evolved stars. If two massive planets exist in proximity about a lone star, one may be ejected (Rasio & Ford 1996). The interstellar planet (brown dwarf) may later be captured by another star or become a solitary protostar. With continuing accretion, stars begin life as infra-red low temperature masses that grow in time. In contrast, the counter intuitive SSM has young stars as giant hot blue objects. Stellar disks, now observed with increasing frequency, rather than interstellar nebulae may now be properly called stellar incubators. The symbiosis between the star and its disk is like that between a spider and its web. The interaction displays a complexity reminiscent of highly evolved biological systems.

Stellar luminosity cycles are observed on many stars. On comparatively dim cool stars they are large relative to the one part in a thousand solar cycle. Short period luminosity variation poses a major dilemma for SSM where fusion is invariant over tens of mega- and gigayears.

The population of aggregates must be adequate to provide the accretion rate required to fuel the stellar fusion process. The observations of Zwicky (1937) and Rubin et al. (1980) show that there is more than adequate mass. A crude estimate

indicates the local interstellar population density (typical?) is consistent with measurement. About $6[10]^{12}$ kg/s impacts the sun (see Sect. 2.5). If about 10% of the trapped mass arrives at the sun, this means $\sim 10^{-9} M_{\odot}/\text{yr}$ is integrated into the solar disk. With an order of magnitude disk interaction cross section of a square light year ($\sim 1 \text{ LY}^2$) and a relative velocity of $\sim 10^{-4} \text{ LY/yr}$, the local density is (order of magnitude) $\sim 10^{-5} M_{\odot}/\text{LY}^3$ ($\sim 10^{-23} \text{ kg/m}^3$). This solar accretion estimated value is size related. Aggregates of initial size $\ll 10 \text{ m}$ cannot reach the sun, but are part of a population with an exponential size distribution steeper than -3.

The solar system exemplifies SAM physics. The gas giant planets modulate and direct agglomerates falling to the Sun. The influence of Jupiter on comet orbits is well documented. The accretion onto these planets produces exospheric super-rotation and a continuing energy supply that exceeds sunlight. The influx interactions are most evident on the anti-solar hemisphere but extend around the planet. As the influx produces a weak plasma, magnetic interaction causes symmetry about the planetary magnetic equator and a banded upper cloud structure.

The encounter of comet Shoemaker-Levy on Jupiter caused x-ray aurora showing how hypervelocity impact can produce high energy radiation. The interaction of the solar wind with comets has been construed to power x-radiation now observed with space borne instruments (Lisse et al. 1996). Comet interaction with hypervelocity clusters better explains observed bursts of x-radiation.

The zodiacal cloud is part of the solar disk. Sunlight scattered from dispersing agglomerates was measured from Pioneer 10 and 11 (Dubin & Soberman 1991). Termed cosmoids (a contraction of cosmic meteoroid) it was shown that the scattered sunlight from dispersing subliming sub-micrometer particles produced all the zodiacal light beyond 1 AU and explained its polarization. If the Pioneer 10/11 measurements were the sole evidence for these near invisible (2 – 3% albedo) clusters, they might be dismissed as spurious. In the following subsections we show that measurements extending back nearly half a century form a massive body of proof for continuing solar accretion of this population.

2.1 Terrestrial influx

Öpik, certain that interstellar meteoroids must exist, concluded over half the sporadic meteors were of interstellar origin. Hotly debated (Öpik 1950) the idea was discarded when no meteors with unambiguous interstellar velocity could be measured. An early indication that cosmoids do not produce classical meteors is seen in the discovery by Ryle and Hewish (1950) of unusual scintillations ($\sim 0.1\%$) of galactic radio sources observed at wavelengths of 3.7 and 6.7 meters. Precise analysis indicated sporadic rapid change increased electron concentrations in the ionosphere *F* region (150 – 300 km) with horizontal extent about 5 km occurred only at night (maximum likelihood near midnight) with no measurable annual modulation. Their analysis concluded the source of these disturbances must have an interstellar origin, entering the ionosphere from solar hyperbolic orbit. Continued effort showed that such increased electron density regions causing the radio scintillations occurred in interplanetary space and preceded solar wind variation (Houminer & Hewish, 1972; Tappin, Hewish, & Gapper 1983).

A decade after Ryle and Hewish's (1950) radio scintillation discovery, a Stanford University team studying 'over the horizon' forward scatter radar at 6 to 30 MHz for military surveillance found sporadic magnetic field aligned ionization occurring in the ionosphere *E* (90 – 120 km) and *F* regions (Peterson et al. 1960). It was noted that the amplitude of the echoes decreased with radio frequency and were more frequently observed at higher latitude (Spokane, Washington relative to Stanford, California). Further, it was noted that these field aligned ionization patches began and faded rapidly, occurring most frequently at night (peak around local midnight). Typical occurrence was at a height of ~ 200 km, many scale heights (~ 6 km) above the ~ 100 km altitude where classic short period meteoroids produce ionization trails that create traditional coherent backscatter radar echoes.

To have escaped identification in meteor studies, cosmoids must have several characteristics. First: inability to produce visual/photographic meteors which would have been measured and from which orbits would have been deduced. As with visual meteors, nearly every aspect including orbits, of radio meteors have been studied for one half century, hence a second characteristic: the ionization trail of this class should be incapable of returning measurable backscatter echoes at normal radar frequencies. As rocket and satellite borne detectors for meteoric particles have been used for one half century, a third need be: unlikely to damage artificial spacecraft surfaces. As such a population should reach the exosphere and likely below, the fourth would be: interaction with the atmosphere need be undetectable with traditional instruments or if noticeable, attributable to established environmental phenomena. We'll show by measurements that cosmoids satisfy all four criteria.

The hyperbolic solar orbit cosmoids that dominate the interplanetary meteoroid population by at least two orders of magnitude, was only recently discovered (Dubin & Soberman 1991) despite prediction and extensive earlier search for their existence. Having concluded from the results of the three independent Pioneer 10 and 11 interplanetary dust experiments that cosmoids were measured, had to be mostly volatile, extremely fragile and easily dispersed; we began an extensive search of the literature for further evidence of their existence and measurement. Although not recognized as such by the investigators, we concluded that cosmoids were observed in the inner solar system by the dust detectors on the HELIOS spacecraft (Grün et al. 1980), the Galileo and Ulysses spacecraft (Grün et al. 1992). Results from the Ulysses dust detector during the Jovian encounter confirmed the interstellar origin (Grün et al. 1993) and demonstrated the dispersion and redirection produced by that planet.

Comet-like (but orders of magnitude smaller) loose ensembles of submicron grains of frozen volatiles, mainly H_2 , H_2O , CO and CO_2 , interspersed with gas atoms, molecules and minor meteoric species, a fraction of the total cosmoid population burst or jet in interplanetary space when structural stresses induced by solar warming are increased by solar activity beyond critical levels. Data from the Pioneer 10/11 instruments, particularly the optical telescopes of the Sisyphus asteroid/meteoroid experiment, showed that sunlight scattered from the dispersing volatile particles before sublimation accounted for all of the zodiacal light brightness beyond 1 AU. The polarization of the zodiacal light is explained by the submicron size of these particles (Dubin & Soberman 1991).

In near radial solar orbit, directed by gravity and ‘non-gravitational’ radiation forces that vary inversely with size (Brandt & Chapman 1981), cosmoids approaching the Earth encounter the antisolar geotail and magnetotail containing high concentrations of energetic electrons. These produce high coulomb and electromagnetic forces that result in dispersion out to tens or even hundreds of Earth radii. Potentials of 10 keV and larger have been measured on satellites passing through the geotail (Garrett 1981). Electrostatic breakup of the weak structure causes progressive subdivision, branching like a tree to form a dispersed cloud of gaseous molecular clusters and submicron frozen grains before reaching the upper atmosphere. As a result, atmospheric interaction is diffused over too large an area to be detected by traditional instruments. In consequence of this magnetotail disruption, unlike most low eccentricity solar orbit meteoroids that have been exposed to sunlight for extended periods, cosmoids do not enter the atmosphere as a solid (albeit of low bulk density for cometary debris). Although the energy per unit mass is larger, dispersion over many square kilometers precludes traditional visual or photographic meteor trails. The Gegenschein, light diffracted by the atmosphere and backscattered ($\approx 180^\circ$) to the Earth from the antisolar direction by these disrupted particles evidence geotail dispersion (Dubin 1986).

While there were earlier observations of night time ionospheric scintillation (Ryle & Hewish, 1950) and coherent field aligned electron trails (Peterson et al. 1960), it was not until newly available high power VLF (2 MHz) radar built for military long range communication was directed at meteors that Olsson-Steel and Elford (1987) measured echoes from a population that produced coherent electron trails at altitudes above 120 km. They concluded this population has an altitude distribution completely different from traditional radio meteors measured at much higher frequency and yields impossibly low densities ($< 10^{-2} \text{g/cm}^3$) when calculated by classical solid meteoroid analysis. They further reported it dominates the meteoroid flux by at least two orders of magnitude. The peculiar high altitudes of these radar signals, extending above 140 km, means that the meteors form ionized trails where the atmospheric density is reduced by a factor of 100 or more relative to the 90 – 100 km classical radio meteor height. The computed low density can be understood as what would result from the atmospheric interaction of a freshly dispersed cloud of particles.

The third cosmoid characteristic listed above was, ‘unlikely to damage spacecraft surfaces.’ One of the concerns in the earliest days of rocket and satellite studies was the hazard posed by hypervelocity meteoroid impact. Experiments to measure the meteoroid flux were among the first placed on high altitude rockets and artificial satellites (Dubin 1960). A controversy developed over the level of the terrestrial micrometeoroid influx as momentum sensitive acoustic microphones and recoverable rocket collections measured a flux about three orders of magnitude larger than crater and penetration sensing instruments that were, in several instances, carried on the same satellites (e.g., Soberman & Della Lucca 1963). As hazard was the primary concern, the lesser fluxes were adopted for spacecraft design (Kessler 1970) while the larger values were attributed to instrument artifact. Subsequent, an ionization sensitive dust detector on the highly eccentric earth orbiting satellite HEOS 2 measured streams of particles that exceeded the penetration flux by 2 – 3 orders of magnitude

(Fechtig et al. 1979). The necessity for protecting one of two similar instruments on the HELIOS interplanetary spaceprobes from direct sunlight revealed a second meteoroid population in eccentric solar orbit that was unable to penetrate the $3.75\ \mu\text{m}$ protective film (Grün et al. 1980).

The fourth characteristic of this interstellar meteoroid population is, ‘its interaction with the atmosphere need be undetectable with traditional instruments or if noticeable, attributable to other atmospheric or meteoric phenomena.’ Our search for signatures of energetic streams from cosmoids interacting with the ionosphere/exosphere centered on trace meteoric constituents. While not as dramatic as the real time measurement of dispersed cosmoid particle streams by radar (Olsson-Steel & Elford 1987) there exist numerous terrestrial and satellite observations of cosmoid stream phenomena. Individually they are not easily interpreted, but together form a pattern providing further evidence of the atmospheric cosmoid meteor signature. Discussion of all or even most of the phenomena and their interrelations is beyond the scope of this paper. Rather, mentioned below are upper atmospheric phenomena (some involving meteoric trace constituents) discovered in the last 15 years with newly available ground and satellite instruments that defy explanation by classic short period meteors. Detailed treatments of these and more are subjects of future communications.

Using lidar, von Zahn and Hansen (1988) found thin neutral sodium layers that appear suddenly (within minutes) at about 95 km above high latitudes, extending horizontally for tens to hundreds of kilometers. Traditional meteors produce diagonal trails that extend downward for many kilometers. A mechanism for converting neutral atoms from many such trails rapidly into a horizontally extended vertically thin layer is unknown. To generate sudden high altitude sodium layers, Dubin (1989) suggested a mechanism from cosmoids, electrostatically transformed by capturing energetic electrons in the geotail, to a cloud of near uniformly sized molecular clusters. As the stream is of one velocity, it is stopped by the atmosphere in a very narrow altitude range, less than a scale height ($\ll 6\text{ km}$). Vaporization, sputtering or photolysis of molecular clusters releases atomic sodium. As the cloud of molecular clusters is weakly charged, the influx is modified by the Earth’s magnetic field, deflecting much of the mid latitude influx to polar regions. The variation with latitude of the upper atmosphere sodium, minima at mid latitudes, implies that the cosmoid component of the meteoroid population dominates the distribution, and also implies early dispersion.

Tuned to an iron resonance line, sudden appearing high altitude sporadic neutral iron layers were discovered with lidar by Bills and Gardner (1990) and Kane, Mui and Gardner (1992). These have similar spatial characteristics to the lidar found sodium, but are measured at a middle latitude. Iron yields a much greater meteoric signature than sodium. Grebowsky and Pharo (1985) using ion spectrometers on satellites have measured iron ions above 140 km extending to 500 km altitude. This is far above the 100 km height of classic meteor ablation. Hypothesized upward electromagnetic transport fails to explain latitude and local time distribution. Observed in resonance fluorescence from satellites and morphologically mapped from the Space Shuttle, Mende, Swenson and Miller (1985) found magnesium ions extending to 500 km.

These recent discoveries of obvious meteoritic atomic and ionic constituents resist explanation by classical short period meteors because altitudes, latitudes, geometry, magnetic field alignment and local times of measurement are inconsistent with that source. Rather, these phenomena may be understood and explained as resulting from the atmospheric interaction of energetic plasma streams produced by the dispersion of cosmoids.

One upper atmosphere visual phenomenon, noctilucent clouds resisted numerous attempts to be described in terrestrial terms (Soberman 1963). Since the late nineteenth century it was known that these tenuous clouds, appearing sporadically in the northern twilight arch above the summer arctic occur about 80 km high. They forward scatter sunlight hundreds of kilometers southward to the surface long after it is in shadow. The predominant water/ice cloud droplets would be dissociated by solar UV if transported from below. The recognition of this mostly volatile population now permits association of the extraterrestrial water with the micrometeoritic nuclei on which rocket studies showed they condensed (Hemenway, Soberman, & Witt 1963).

Ecklund and Balsley (1981) detected coherent radar echoes that peaked at about 85 km, extending for horizontal distances larger than 30 km over northern Alaska during the summer; altitude and distribution in good agreement with noctilucent cloud occurrence. Measured ionization at that altitude cannot account for coherent radar echoes at the frequencies used. While the above and other cosmoid associated manifestations (e.g., other electromagnetic emissions) will receive extended treatment in the future, they are mentioned here to establish, beyond question, the terrestrial influx of this population.

2.2 Continuing accretion on the giant planets

The giant planets with their own disks of rings and moons evidence continuing accretion. Rings that lose mass to the planet require continuous resupply (Esposito et al. 1984). Clues to the mechanism were in the radial spokes first observed by the Voyager cameras (Smith et al. 1981, 1982) that appear randomly in the shadowed portion of Saturn's rings. The interaction of narrow elongated hypervelocity streams of dispersed macromolecules and microparticles with the orbiting ring particles produce radial spokes that diffuse as the collisional disturbance is dissipated. The very intense short radio bursts detected on Voyager 2 by the Plasma Wave (Gurnett et al. 1989) and Planetary Radio Astronomy Experiments (Warwick et al. 1989) near Neptune likely were similarly generated by such interactions.

Dispersion and a strong gravitational dust concentration produced by Jupiter were observed during Ulysses' planetary encounter. Velocity measurements established that the interacting cosmoids were in hyperbolic solar orbit hence interstellar (Grün et al. 1993).

Stronger evidence for the continuing accretion of cosmoids is found in the atmospheric high temperatures, super-rotation and banded cloud patterns seen on the giant planets (for which no satisfactory explanation exists in SSM). Spectra of the hydrogen Lyman α line in Jupiter's upper atmosphere show supersonic velocities from several to tens of kilometers per second (Emerich et al. 1996). The prograde bias resulting from interaction with the disk, solar wind and more remote planets produces

a torque in the momentum derived from cosmoid accretion that drives the exospheric super-rotation. The process (fluid shear) is treated subsequently in Sect. 2.5 where a solar consequence is explained. Jupiter's supersonic winds and hydrogen bulge, for example, derive from the infall mass velocity components, i.e., solar escape, Jovian orbital and escape. The dispersed streams impacting on a rotating atmosphere produce longitude spread while the electromagnetic interaction of the plasma with the bipolar magnetic field results in a banded wind (upper cloud) structure that displays symmetry about the geomagnetic equator.

The influx of this matter at a combination of solar plus planet escape speeds profoundly effects the energy budget of the planets. This is of great import for the gas giant planets far from the Sun. Jupiter's exosphere, for example, is heated by the infalling dispersed plasmas to a temperature of about 1,000 K as measured from Voyager (Festou et al. 1981) and confirmed from the Galileo Probe (Seiff et al. 1997). This is also the mechanism heating the corona to $2[10]^6$ K (discussed subsequent). As the gravitation energy is predominantly inverse to solar distance, it is three orders of magnitude less at Jupiter where the influx is mostly restricted to the night hemisphere yielding an additional factor of 2 decrease relative to the coronal temperature. Evidence of this influx is also seen on Venus, particularly in the shadowed hemisphere.

2.3 The zodiacal influx

At extreme temperature within several solar radii (R_{\odot}), particles in low eccentricity slow Poynting - Robertson spiral orbit should vaporize, creating a predicted dust free zone. No dust free zone was found near the photosphere in more than two decades of searching. Two measurements made during the 1991 solar eclipse add to the numerous IR observations showing the zodiacal dust not just extending but increasing to the solar disk (Lamy et al. 1992; Hodapp et al. 1992). Close to the disk, volatile dust could only exist briefly, as in near radial hypervelocity influx, before sublimating. While radiation pressure may exceed gravitational pull for ablated dust and gas from high velocity comet-like agglomerates, inertia produces continued streaming at hundreds of kilometers per second (only slightly decelerated, if at all), in the brief period required to reach and penetrate the photosphere. Hicks, May and Reay (1974) discovered that the solar corona had a significant inward radial velocity from measured doppler shifts of several Fraunhofer lines. With improved doppler measurement, Fried (1978) confirmed that within 0.7 AU the dust responsible for this component of the F corona was streaming into the Sun with near escape velocity. Using a photoelectric radial velocity spectrometer that scanned 17 Fraunhofer lines, Beavers et al. (1980) measured two populations, one in prograde orbit beyond $4 R_{\odot}$ and a second falling into the Sun with velocities from about 50 to 250 km/s at about that same solar distance. This infall represents the continuous streaming of particles through the corona, continuing mass accretion by the Sun from interstellar space.

2.4 The corona

The existence of a coronal temperature of two million kelvin (2,000,000 K) above a 6,000 K chromosphere has been an enigma. Attempts to transport energy from the solar interior have failed. Bondi, Hoyle and Littleton (1947) showed that collision

with infalling interstellar hydrogen would provide the required coronal heat, but the idea was discarded when it was recognized that gas and fine dust would be blown away by the solar wind. Aggregates with an area to mass ratio $< 10^3 \text{ m}^2/\text{kg}$ falling with near escape velocity ablate gas and dust that heat the corona by collision.

Announced on 11 June 1996 by experimenters using the Ultraviolet Coronagraph Spectrometer (UVCS) aboard the Solar and Heliospheric Observatory (SOHO) spacecraft was the detection of one hundred million kelvin (10^8 K) oxygen ions in a ‘quiet Sun’ coronal hole. The temperature had not peaked at $1.9 R_\odot$. In the same solar structure, protons reached a peak of $6[10]^6 \text{ K}$ at $2 R_\odot$ then gradually fell off. Separate measures showed the electrons at about one million kelvin (Glanz 1996). Low mass electrons would be the first to reach thermal equilibrium in the comparatively cooler coronal hole. The equivalent temperature of ions falling radially into the Sun at escape velocity is:

$$T = \frac{2GM_\odot m}{3kR} \quad (1)$$

For oxygen at $1.9 R_\odot$ this is $\sim 130[10]^6 \text{ K}$ and for protons at $2 R_\odot$ it is $\sim 7.5[10]^6 \text{ K}$. High mass proportional ion temperatures in the corona, baffling under SSM, provide additional proof of continuous accretion.

2.5 Differential solar rotation

When it was discovered that the tangential velocity of spiral galaxies, including our own, does not decrease at large distance from the center in a Keplerian manner, additional mass beyond the perimeter was theorized to explain the anomaly (Rubin et al. 1980). Similarly, the accretion of interstellar agglomerates with a prograde bias derived from disk, planet and solar wind interaction provides the torque to drive differential solar rotation (akin to planetary exosphere super-rotation above. No satisfactory internal driving mechanism has been offered to explain a tangential velocity that increases with increasing distance from the rotation axis. The equatorial velocity, $\sim 2 \text{ km/s}$ in comparison to the infall velocity $\sim 600 \text{ km/s}$ indicates the tangential momentum transfer. Disk (including planetary) interactions also cause the influx to increase toward the equator. The measured variation of the rotation velocity with latitude over the solar cycle (Woodard & Libbrecht 1993), inconsistent with internal inertial driving mechanisms, follows from the disk modulated influx.

The differential rotation may be used to provide an order of magnitude estimate of the accretion rate that cannot be derived from current interplanetary measurements. If we assume a simple two dimensional fluid between two parallel surfaces a distance l apart, one of which is moving with a tangential velocity u_l relative to the other (Fig. 1), then we may describe the shear by the relation:

$$P = \mu \frac{du}{dl} \quad (2)$$

where P is the pressure and μ the fluid viscosity. If the pressure results from the infalling momentum, we can approximate:

$$\frac{v_e}{A} \frac{dm}{dt} = \mu \frac{u_l}{l} \quad (3)$$

where we assume that the influx momentum is transferred in the depth l and *the interior has negligible spin*. For the solar surface viscosity we use 10^4 Ns/m^2 from the

kinematic viscosity (the viscosity divided by the density) chosen by Rüdiger (1989) in his book on differential stellar rotation citing an earlier dissertation on the subject (Köhler 1969). For the photospheric density we use 10^{-4} kg/m^3 . We estimate l to be 10^7 m on the assumption that the mean free path at that depth should be sufficiently small to completely stop the infall. The mass influx required to maintain the observed differential rotation against viscous drag is order of magnitude $\sim 10^{-6} \text{ kg} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$.

An argument used for many years to show that continuous accretion could not gravitationally power the Sun (hence the need for fusion), is that measurements of the length of the terrestrial year would have detected even small increases in the Sun's mass. We do not doubt that fusion provides most of the Sun's power, but challenge SSM in where it is occurring (see below). Using the order of magnitude mass influx determined above i.e., $\sim 10^{-10} \text{ M}_{\odot}/\text{year}$, the annual change over several millennia would be several seconds or within long term record uncertainties.

In this section we described a number of observations showing the Sun, its disk and planets continuously accrete a significant amount of interstellar mass in the form of clusters (cosmoids). Included were high coronal temperatures, doppler measurements of a radial component to the zodiacal cloud, differential solar rotation and several planetary and interplanetary observations. Further evidence of continuing accretion is presented in describing some consequences of electromagnetic behavior and stellar encounter. As above we rely heavily upon measurements of our Sun, a typical star.

3. Stellar Plasma Impact

Agglomerated in intergalactic space, super-cooled super-conducting randomly rotating cosmoids may have their own bipolar fields. Near a star, interactive jetting produces a plasma tail of microparticles, macromolecules, ions and electrons.

As a rule, cosmoids strengthen a magnetic field they encounter. This may seem to contradict Lenz's law. It does not. Lenz never considered other than electromagnetic forces. The gravitational force in the presence of a massive body overrides the repulsive electromagnetic force to the infalling plasma.

In the absence of a magnetic field, an infalling cosmoid will create one. The plasma, like any fluid develops a Coreolis vortex of neutrals and ions. This generates an axial magnetic field in which the electrons flow. The axial magnetic field enhances the vortex by pinching the gravitationally accelerating current. The outward extending field acts as a magnetic funnel to guide other plasmas in similar orbits. Thus once such a vortex is established it will persist, strengthen or weaken, depending on the supply of accreting matter.

Concentrated by stellar gravity, cosmoids like comets are modulated and directed toward the central star by the giant outer planets (Cowen 1996). Only as clusters with an area-to-mass ratio sufficiently small for gravitational attraction to overcome radiation pressure can this material approach a star. For Sun this limit is $< 10^3 \text{ m}^2/\text{kg}$. Ablation from stellar heating destroys small cosmoids and causes the remainder to shrink in size as they approach the Sun. Comets typically ablate more than a meter of surface thickness to generate coma and tail during a single perihelion passage. Sun impacting comets (Michels et al. 1982), too small for detection far from the Sun,

are frequently observed in coronagraphs to enter the solar disk and disappear. One, photographed by the large-angle spectrometric coronagraph (LASCO) on the SOHO spacecraft was featured on the front page of the February 25, 1997 issue of *Eos*, newspaper of the American Geophysical Union. Improved space based coronagraphs will increase observations of impacting comets as small size increases impact likelihood.

Radiation caused jetting, characteristically observed in comets (Sekanina & Larson 1986) produce the so called non gravitational forces (Brandt & Chapman 1981) that vary inverse to the size of the body. Thus, the star's radiation directs approaching cosmoids to impact the stellar atmosphere with near radial, near escape velocity. As the cosmoid composition is hydrogen dominated and ablation keeps the interior cold (as observed with long period, near hyperbolic orbit comets), hydrogen also dominates the remnant. Within several stellar radii inertia permits even ablated gas and submicrometer particles to reach the surface only modestly slowed by radiation pressure.

The impacting plasma, squeezed by the magnetic pinch arrives at the solar surface with a velocity of about 600 km/s. For a proton this is 2 keV, well above the critical energy for the proton-proton (PP) fusion reaction (Fig. 2). The hydrogen encounters the ambient atmosphere with the force of a metaphorical sledge hammer but magnetic pinching converts that force into a metaphorical pickax with attendant effect creating extreme local high pressure. While thermalization is counterproductive and does not occur until much later, we note that the equivalent temperature of the pinched monovelocity proton beam is $15[10]^6$ K, the hypothesized mean solar core temperature.

If the mean PP reaction time was as long as the classically computed core fusion value of $14[10]^9$ years (Clayton 1968), apart from increasing the surface deuterium and helium slightly, it would be extremely difficult to observe effects. Rather, this hypervelocity, downward directed, magnetically pinched proton dominated beam reacts many orders of magnitude faster with stationary ambient protons than calculated from the equivalent temperature. SSM assumes an isotropic, thermal velocity distribution, whereas the beam protons are of uniform velocity, unidirectional and magnetically confined. A few beam protons fuse with ambient protons to produce a small number of MeV deuterons which produce MeV ^3He nuclei that fuse to form MeV ^4He nuclei and MeV protons (Fig. 2). For each ~ 600 km/s influx proton that fuses, we derive one daughter proton moving with $v > 20,000$ km/s, equivalent temperature $> 10^{10}$ K plus additional excited protons that collided with the daughter helium nuclei. It is this energetic proton multiplication factor of unity less inevitable losses that limits the fusion reactions' explosive growth. At MeV velocity, equivalent to a temperature that is three orders of magnitude greater than the fusion initiation temperature or the hypothesized stellar core temperature, the coulomb barrier is overcome and the probability (cross section) for protons to fuse with ambient protons is increased exponentially. Bosman-Crispin, Fowler and Humblet (1954) compute the exponent to be 4.5 for $\sim 10^7$ K decreasing for higher temperatures. For interactions subsequent to the initial influx proton beam collision, the cross section or probability of fusion should increase by at least 12 orders of magnitude with a similar decrease in the reaction time, resulting in an explosion of a size proportional to the mass of in-

flux protons. This estimate is many orders of magnitude larger than the theoretically calculated PP MeV cross section and contrasts to measured carbon-nitrogen-oxygen (CNO) hydrogen-to-helium fusion reaction cross sections, also involving weak beta decays at those energies. As carbon, nitrogen and oxygen are present in cosmoids and the Sun but, as discussed below, observation indicates that PP is the dominant solar reaction, it appears that the PP reaction parameters and nuclear environment requires reexamination.

Another mechanism that may be involved in stellar continuing accretion outer zone fusion is muon catalysis (Alvarez et al. 1957). In the hypervelocity encounter environment short lived muons may replace electrons in hydrogen molecules enhancing fusion reactions.

Stellar outer zone nuclear fusion (F_{oz}) is no longer so bizarre as it would have seemed before Terekhov et al. (1993) observed the 2.2 MeV gamma ray line of the $P(n,\gamma)D$ reaction from the GRANAT satellite during the solar flare of May 24, 1990. Derentowicz et al. (1977) demonstrated that fusion could be produced by high velocity impact. Cluster-impact fusion in the laboratory adds credence to F_{oz} . Initial reports measured orders of magnitude higher rates of deuterium fusion than expected when nanometer heavy water (D_2O) clusters were modestly accelerated to impact titanium deuteride (TiD) targets (Beuhler et al. 1989). In subsequent literature exchanges even critics agreed that fusion occurred. In question was the possibility of contaminant deuterons accelerated to high velocity in the apparatus. After careful separation, it was announced that most of the heavy ($[D_2O]_n$) and normal water ice cluster ($[H_2O]_n$) fusion observed was due to contamination, however factors of 2-4 enhancement over individual DD and DP fusion interactions remained, the consequence of oxygen and molecular ion momentum exchanges and yet to be determined effects (Bae et al. 1993). These results show that when plasmas containing clusters of nuclei, including oxygen and carbon nuclei collide, fusion is more probable than computed from single nucleon-nucleon interaction. It is possible that higher velocity ions formed within the clusters during acceleration, an inseparable part of the cluster acceleration process, may be mistaken for contamination.

As carbon is present in stellar atmospheres and cosmoids, at the increased explosion proton velocity the CNO cycle or bi-cycle (for the two possible reaction chains) is likely to occur even though the influx protons may have been too slow to initiate these reactions. We do not detail the CNO paths, except to point out that these hydrogen to helium fusion chains require an initiation temperature about three times higher than PP. However, above the starting temperature, the classically computed reaction cross section increases much faster than PP so that it is supposed to dominate above $18[10]^6K$. Bosman-Crispin, Fowler and Humblet (1954) compute a CNO temperature exponent of 20 for $\sim 10^7K$ decreasing to 10 for higher temperatures. Thus, CNO hydrogen fusion, proceeding faster, should dominate at MeV energy when carbon is present. Observations of daughter isotopes in stellar atmospheres and neutrinos from our Sun indicate the dominance of PP over CNO fusion even for higher surface temperature stars. This may be the result of understating the PP reaction rate at MeV energies.

Below the photosphere, opacity hides most fusion explosions although some are

likely associated with chromospheric UV “explosive events,” while larger reactions are likely the regularly observed (but SSM enigmatic) bright points (Golub et al. 1974; Howard et al. 1979); sporadic transient isolated x-ray flashes with temperatures exceeding 10^6K (~ 1500 are estimated on the Sun at any given moment). From meteor studies, the atmospheric depth at which maximum deceleration (interaction) takes place is where the mean free path becomes comparable to the size of the decelerating body (McKinley 1961). Thus, the pinched cosmoid beam likely penetrates deep ($\sim 10^7\text{ m}$) before exploding. As discussed later, only in the occasional flare may we observe fusion occurring above the photosphere. As the atmosphere has comparatively low pressure to great depth below the photosphere in most stars, the fusion fireball expands rapidly. Discussed above, the energetic proton multiplication factor is exactly 1, meaning that losses limit the chain reaction to a size proportional to the number of protons in the initiating cosmoid created plasma beam. Apart from spots (discussed subsequent), these sporadic, normally unconnected, explosions are distributed randomly, with the opacity and heat capacity of the sub-photospheric fusion region averaging the power produced like a cloudy sky diffuses sunlight.

As most energy production occurs thousands of kilometers beneath the photosphere, the deeper central regions remain static except for the settling of fusion products and small amounts of higher density influx material. Gradually, differentiation separates the elements. For a population I composition, elements heavier than helium, comprising 3-4% of the mass, occupy the central few percent of the radius, helium fills the core to ~ 0.2 radii and hydrogen dominates above. With no internal fusion and the heat source in a surrounding shell, the temperature within is near uniform. The maximum occurs in the outer zone fusion shell with a steep negative temperature gradient from there to the photosphere. This is a convective region made turbulent by magnetically confined infall plasma streams and radiation propelled escaping solar wind ions. The photospheric temperature is a thermal balance between the several million kelvin fusion shell below and radiative cooling to the cold (3 K) sky. Its value is maintained by the heat capacity of the entire stellar mass. As the spatial density of cosmoids varies, modulated by gravitational interaction with the planets, during periods of reduced influx, thermal energy is supplied by the stellar interior to maintain the visual and long wavelength (bolometric) luminosity. With large flux variations the luminosity of some stars fluctuate dramatically. During active periods the higher energy (UV, x- and gamma ray) stellar luminosity increases with the flux of initiating cosmoids and resulting fusion.

Hypothetical SSM core fusion (F_c) and SAM outer zone fusion (F_{oz}) require different PP reaction rates that assure mutual exclusivity. F_c requires that energy be released slowly, commensurate with estimated stellar life. Measured luminosity and limited hydrogen set a SSM boundary condition for the PP reaction time. The theoretical $\sim 10^{10}$ year value results in a computed deuterium/hydrogen ratio of 10^{-17} in star cores, a value inconsistent with surface observation by $> 10^{12}$ and recognized as a problem (Clayton 1968). It is noteworthy that the PP fusion reaction time varies approximately proportional to the concentration of the daughter deuterons, i.e., a larger local D/H ratio increases the speed with which protons fuse. The relatively high amount of deuterium observed in stellar atmospheres supports F_{oz} .

A second requirement for slow reaction prevents the star from exploding when core fusion conditions exist. To meet these requirements, F_c models ignore collision and daughter proton velocity (effective temperature) that increase effective cross section and reduce reaction time. In contrast, F_{oz} requires explosive reaction, constrained by the infalling hydrogen mass. Particle plus radiation efficiency losses reduce the inherent energetic proton unity multiplication factor to yield a fireball with limited growth potential. Thus, the stellar PP reaction rate forms the critical difference making outer zone and core fusion mutually exclusive.

4. Proof of continuing accretion driven stellar fusion

Two independent teams measured ^7Be on the leading surfaces of the Long Duration Exposure Facility (LDEF), retrieved after orbiting the Earth for 69 months (Fishman et al. 1991). The concentration necessary to account for the measurements was several orders of magnitude greater in orbit than in the stratosphere ~ 300 km below. In the troposphere and stratosphere, radioactive ^7Be (53 day half-life) is accepted as the consequence of high energy cosmic ray spalling of nitrogen and oxygen mostly between 15 and 20 km (Arnold & Al-Salih 1955). With orbit altitude production inconsequential, a fast vertical transport and concentration mechanism was sought. To bolster that hypothesis, pieces of LDEF were examined for ^{10}Be , a radioisotope with a 1.5 million year half-life, similar chemistry, spallation production and transport likelihood. Unexpected, the only ^{10}Be found was inherent in the aluminum, as about the same was found on interior and control surfaces and it did not exhibit the ^7Be 100 times leading to trailing surface excess (Gregory et al. 1993). This leads the investigators to conclude that cosmic ray spallation is a most improbable source.

Fusion is the remaining method to produce ^7Be with the Sun the sole source consistent with known astrophysics. Further, the half-life only permits the ^7Be to originate near the surface. A SSM derivative, standard solar model (also SSM) tables show core fusion 10^{19} short of providing an adequate amount for the LDEF measurements (Bahcall 1989). A straightforward computation (Dubin & Soberman 1996) shows that to obtain the $5[10]^9$ $^7\text{Be}/\text{m}^2$ the two teams found on the leading LDEF surfaces (Fishman et al. 1991), requires most fusion occur near the solar surface. These seminal beryllium measurements incontrovertibly prove accretion driven outer zone fusion unless/until a physically reasonable alternative source is found.

5. Continuing accretion (SAM) versus nebula collapse (SSM) argued

We begin with an apology for our characterization of the standard stellar model (SSM). We do not demean nor trivialize the profound theoretical efforts incorporated. Science is however, humanity's best guesses to explain limited observations. It is the wealth of new observations, unimagined during SSM's development, that facilitated reappraisal of the founding assumptions.

The generally accepted model theorizes stars born in the collapse of a cold dense dust and molecule containing gas nebula. Binaries and clusters form from the same nebula simultaneously or nearly so. The stellar mass is fixed (Russell - Vogt theorem) and invariant. Stellar winds and binary mass exchanges later modified mass invariance and core fusion was appended.

In the near gravity free nebula environment coherence is a lengthy process, even by cosmic standards, and computer simulated collapse in (simulated) reasonable times is neigh impossible (Foster & Boss 1996). Compounding the difficulty, SSM requires collapse times vary inversely with the mass of the resultant star(s). Fusion initiation must be inserted by hand as collapse computer models are unable to achieve the requisite conditions. An obvious problem is that hydrogen fusion must begin in the one place (the center) from which gravitational differentiation would quickly remove it.

Bethe and Critchfield (1938) chose the stellar core for the required temperature and pressure. That also provided long term stability, commensurate with stellar lifetimes. Gravitational variation has a time constant of the order of ten million years while the hydrogen fusion process is theorized to have a time constant of about ten gigayears. Photons initiated in the stellar core take millions of years to reach the surface by random walk scatter. Long term stability is, however, inconsistent with stellar luminosity and wind variation, occurring in times extending from milliseconds.

UV observations of stellar winds present an enigma to SSM. Inexplicable in isolated hydrostatically stable stars, the strongest would cause massive stars to evaporate before they exhausted their theorized fixed fuel supply. Thomas (1993) detailed several aspects of the incongruity between SSM and recent wind observations.

Solar measurements with recently developed instruments confound SSM theoreticians. The situation has grown worse in the near two decades since Parker (1978) wrote “Indeed, the activity of the sun provides so many effects outside the realm of conventional laboratory physics that its contemplations is a humbling experience for the serious physicist, repeatedly demonstrating the incorrect nature of our best ideas and explanations.”

If the LDEF beryllium measurements cited in the preceding section are proof of continuing accretion, why do we deem it necessary to proceed? Experience has taught that a singular proof, lacking an explanation consistent with SSM, will be rejected. In upholding the editorial decision to refuse publishing our conclusion based upon the cited high signal to noise measurements, the Editor-in-Chief of the American Physical Society wrote “It is simply not acceptable to focus on one empirical set of data, at the cost of jettisoning an entire body of experimental and theoretical work” (Bederson 1996). All arguments (cum citations) showing that the standard model is contradicted rather than supported by experiment were ignored. The beryllium results were never in question!

The case against SSM and for a revised continuing accretion anatomy of stars is founded upon a plethora of measurements. For each set, we present first the SSM explanation (when we are aware of one generally accepted). Thereafter we provide the continuing accretion SAM explanation. The reader should compare as would a jurist. Beginning with three critical observation sets previously listed, the order thereafter takes advantage of information developed for the reader who may not be familiar with some of the diverse specialties we draw upon. We admit to a biased presentation for the prosecution. However, the informed reader is familiar with volumes of arguments for the defense. In recalling the SSM explanations and interpretations it should be

kept in mind that, with the exception of neutrinos (see below), only the surfaces (and above) of stars are observed. All else is inference and conjecture.

Stellar luminosity variations

SSM: Incompatible with invariant core fusion, there have been many attempts to provide energy storage in metastable atomic levels and magnetic field twisting. None have proved convincing.

SAM: With fusion controlled by a variable surface accretion rate, luminosity may change on any time scale, subject to moderation by energy transport from the interior.

Stellar winds

SSM: No explanation consistent with hydrostatic equilibrium exists.

SAM: Fusion radiation propelled near surface plasma plus sublimation from infalling agglomerates fuels the wind and explains its variability.

Missing nebular angular momentum in stars

SSM: Complex disk magnetohydrodynamic braking and jets in ‘young’ stars (Ouyed et al. 1997; Ray et al. 1997).

SAM: Problem unique to SSM.

Angular momentum discrepancies in the solar disk

SSM: Hypothesized early planetary collisions.

SAM: Other than an interactive disk/star/planet rotation bias, continuing accretion requires no short term consistency.

High temperature giant planet exospheres

SSM: Van Allen particle precipitation, ionospheric current heating and gravity wave dissipation have been proposed.

SAM: Accretion heating matches measured temperatures (see Sect. 2.2).

Planetary exosphere super rotation

SSM: No explanation.

SAM: Driven by accretion (see Sect. 2).

Banded cloud structure on giant planets

SSM: Planet rotation plus internal heating explanations sought.

SAM: Driven by accretion (see Sect. 2).

Terrestrial exospheric VLF meteors

SSM: No explanation.

SAM: Accreting cosmoids (see Sect. 2).

Sudden appearing meteoric trace constituent layers

SSM: No explanation.

SAM: Produced by dispersed cosmoids (see Sect. 2).

Noctilucent clouds

SSM: A rapid vertical water transport mechanism is sought.

SAM: A result of magnetically directed accretion.

Gegenschein

SSM: No explanation.

SAM: Refracted sunlight backscattered from the dispersed cosmoid microparticle geotail (see Sect. 2).

Solar cycle - terrestrial climate link - Climatologists have long been aware of the correlation between terrestrial climate and the solar cycle. Particularly evident in tree rings (e.g., Currie 1992), the link has been taken seriously only in recent decades because SSM provides no reasonable causality. Solar luminosity varies only in the third significant digit, too little to significantly effect global weather.

SSM: No explanation.

SAM: Continuing accretion modulated by the giant planets varies $\pm 25\%$ or more, creating the solar cycle. With that variation, the terrestrial water influx of cosmoidal origin descending through the dry stratosphere produces albedo altering cirrus clouds plus other climate modifiers.

Terrestrial aurora precede solar disturbance - Silverman (1983) created a perplexing dilemma for theorists when he discovered that terrestrial aurora predict solar activity.

SSM: Aurora are consequences of solar disturbances propagated through the solar wind, despite the wind's inability to penetrate the magnetopause (Chappell et al. 1987). In light of Silverman's discovery, this explanation violates causality.

SAM: The mechanism by which accreted dispersed aggregates are magnetically directed to produce the aurora is a subject for future papers. However, it is readily understood that enhanced numbers of such aggregates must first transit the Earth's orbit before arriving on the Sun to cause a disturbance.

Rings around planets

SSM: Gravity escaping debris from meteoric erosion of moons provide the necessary continuing particle source. Despite recognition of an interstellar source at Jupiter, Grün et al. (1996) deem it insufficient to explain the measured dust concentration.

SAM: Dispersion of agglomerates provides the observed captured rings, accretion and hyperbolic encounter microparticle streams.

X-rays from comets

SSM: Solar wind explanations have difficulty with cometary x-ray and extreme UV emission, particularly bursts of such radiation (Lisse et al. 1996).

SAM: Collisional excitation of ablated mass from hypervelocity clusters provide the requisite energy and explain why such radiation is more likely near perihelion.

Zodiacal matter accretes on Sun

SSM: A non existent 'dust free zone' around the Sun was predicted.

SAM: Several independent experiments have found a population falling toward the Sun with near escape speed (see Sect. 2).

High temperature corona

SSM: Theoretical efforts to heat the corona from below have, without exception, failed.

SAM: The calculations of Bondi et al. (1947) show how sublimated mass from infalling clusters (which they did not consider) heat the corona to $2[10]^6$ K. As shown in Sect. 2, this also explains the SOHO $[10]^8$ K oxygen measurement (Glanz 1996).

Differential solar rotation

SSM: Physics provides no mechanism to internally cause the outer extremes of a body to continue to spin faster than the body.

SAM: Continuing accretion provides the required external power source.

Helioseismology

SSM: Short period (e.g., 5 min.) solar surface acoustic oscillations are attributed to the turbulent subsurface layer (Hill et al. 1996) as resonant wave motion can not be sustained far from the power source. Long period ($> 10^7$ yr) invariant core fusion, removed $\sim 1R_{\odot}$ from the surface, is near impossible to reconcile with sustained rapid acoustic oscillation.

SAM: Continuing accretion and associated fusion results in outer zone turbulence powering acoustic eigenmode surface resonances.

Sunspots

SSM: No satisfactory explanation exists.

SAM: In Sect. 3 it was explained how infalling plasma vortices create vertical magnetic field funnels that guide continuing supplies of accreting plasma. A large sustained influx causes the field lines to strengthen and close, creating a pair of spots overlying intense fusion regions. The cold influx explains the cooler temperatures and molecular spectra observed (Sandlin et al. 1986).

Sunspot drift rate - Libbrecht and Morrow (1991) measured the speed with which sun spots travel within the photosphere. They found the small spots move about 2% faster than large spots.

SSM: No explanation is compatible with an interior driving mechanism.

SAM: With an exterior force applied, Fig. 1 shows that the deeper a large vortex extends, the slower it moves due to fluid shear drag.

Flares - Occurring at the apex of magnetic flux tubes, they exhibit temperatures $> 0.5[10]^6$ K and are accompanied by bursts of gamma radiation indicative of nuclear reactions. The 2.2 MeV line observed in the solar flare of May 24, 1990 showed $^1\text{H}(n,\gamma)^2\text{H}$ occurring (Terekhov et al. 1993). The 0.5 MeV signature of positron-electron annihilation has been seen (Ramaty & Lingenfelter 1979) and large excesses of ^3He are associated with solar flare observations (Schaeffer & Zahringer 1962).

SSM: Core fusion provides no satisfactory explanation for flares. Hypothetical magnetic reconnection is too slow.

SAM: A large cosmoid, more common during active periods, that cannot be magnetically guided into one of a sunspot pair, will occasionally strike

the field line apex. Disrupted by the $E \times B$ force, fusion initiated at the apex, interacting with the magnetically associated dual pinched reaction zones, provides huge local power sources that may persist for hours. The field lines permit energetic protons plus heavier ions to escape.

Spicules

SSM: No clues are offered to the origin or nature of spicules that rise 5 to 20 km through the chromosphere and may persist for minutes.

SAM: The pinched column of infalling plasma sits atop a fusion reaction zone. Energetic ions propelled back along the magnetically confined column interact with the plasma influx to a maximum height set by the reaction intensity below. When the influx abates, so too the resultant spicule.

Solar mass ejection - Also called coronal mass ejection (CME), these huge masses (10^{12} kg) depart the sun with velocities ≥ 400 km/s, no deceleration, most often near solar maximum (de Jager 1986). With thermal energies $10^{23} - 10^{24}$ J, they are accompanied by bursts of gamma radiation from the photosphere indicative of nuclear reactions. They are observed on many stars (Drissen 1992). Early results from the large-angle spectrometric coronagraph (LASCO) on the SOHO spacecraft shows pairing connected by quadrant scale magnetic loops (Brueckner 1996).

SSM: Hildner (1986) among others dubbed them mysterious.

SAM: Relatively large (> 100 m) and consequently sparse cosmoïd arrivals producing sizable fusion explosions provide the power for these events that may link magnetically on a global scale.

Solar neutrinos - Neutrino detections are unique in measuring fusion. As neutrinos interact extremely weakly with nuclei, most will depart the sun independent of the fusion locale. Measurements of four experiments (Homestake, Kamiokande, GALLEX and SAGE) detecting different neutrino energies, hence fusion reactions (Fig. 2) have created havoc because they contradict accepted theory on the following five points:

- 1) About 30% to 60% the number of neutrinos predicted are measured.
- 2) Reported Homestake solar cycle neutrino variation (Rowley et al. 1985), correlated with several solar surface related parameters; acoustic (Krauss 1990), magnetic (Oakley et al. 1994), and solar wind (McNutt 1995) violate long term invariance.
- 3) Neutrino flux surges noted in Homestake results coinciding with major solar flares (Bazilivskaya et al. 1982; Davis 1987) are forbidden by core fusion. The correlation between a great solar flare and Homestake neutrino enhancement was tested in 1991. Six major flares occurred from May 25 to June 15 including the great June 4 flare associated with a coronal mass ejection and production of the strongest interplanetary shock wave ever recorded that was later detected from spacecraft at 34, 35, 48, and 53 AU (Gurnett et al. 1993). It also caused the largest and most persistent (several months) signal ever detected by terrestrial cosmic ray neutron monitors in 30 years of operation (Webber & Lockwood 1993). The Homestake exposure (June 1 – 7) measured ~ 5 times the flux of the preceding and following runs, > 6 times the long term mean and $> 2\frac{1}{2}$ times the highest measurements recorded in ~ 25 operating years (Davis 1994).

4) Results from two detectors are apparently discrepant. Homestake, believed to measure neutrinos primarily from the ^8B reaction (Fig. 2), reports $\sim 35\%$ of prediction, while Kamiokande, that should measure, almost exclusively, the same ^8B neutrinos reports $\sim 50 - 60\%$ the predicted value.

5) The various reported neutrino measurements arising from the several neutrino producing reactions of the fusion chain also produced a ‘paradox’ (Bahcall 1994; Raghavan 1995). The results when compared to model prediction appear to show no neutrinos from the ^7Be reaction, but $\sim 50\%$ of the predicted number from the ^8B reaction. As ^8B results from ^7Be (Fig. 2), measuring neutrinos from the daughter reaction while absents those from the parent is paradoxical.

SSM: 1) Predictions from SSM models (e.g., Bahcall & Pinsonneault 1992) exceed solar neutrino measurements by 165-300% (Bahcall et al. 1995). SSM’s apotheosis is inherent in the several ad hoc hypotheses generated to explain the discrepancies, e.g., the Mikheyev-Smirnov-Wolfenstein (MSW) neutrino flavor change (Mikheyev & Smirnov 1986) requiring a neutrino mass that remains to be reliably measured.

2) All Homestake variations are rejected as statistically inconclusive.

3) Explained as statistical fluctuation or cosmic ray produced (Bahcall 1989). Attributing the 1991 burst (coinciding with the largest recorded solar flare) to statistical variation stretches probability to the point where there is as yet no comment.

4) No explanation.

5) No explanation.

SAM: Outer zone fusion driven by varying accretion permits resolution of all elements of the solar neutrino puzzle consistent with all present measurements (Dubin & Soberman 1996), a feat deemed impossible with any modification of stellar physics (Bahcall 1996).

Anomalous cosmic rays - Very low energy (< 10 MeV per nucleon), they were discovered only when cosmic ray detectors traveled beyond the Earth’s magnetosphere (Hovestadt et al. 1973; McDonald et al. 1974). Anomalous because their elemental abundances differ significantly from galactic and solar cosmic ray populations, they increase with solar distance and do not correlate with solar proton flux. Rich in oxygen, nitrogen, helium and neon, Klecker et al. (1977) showed that for those of energy < 4 MeV per nucleon the elemental abundances were close to those of the solar atmosphere.

SSM: No explanation.

SAM: The interaction between infalling cosmoidal matter, galactic cosmic rays and the solar wind is the source of anomalous cosmic rays. Interaction between the solar wind and cosmoids produce an outer layer on the latter that is comparatively rich in fusion products. These include CNO bicycle products and heavier elements fused in an environment rich in high energy ions. Neon is favored because it can result from several fusion paths.

Deuterium/hydrogen ratio

SSM: As deuterium reacts rapidly with hydrogen, it is hypothetically destroyed during early nebula collapse (Ezer & Cameron 1966) and fused almost immediately in core fusion. Slow F_c requires ratios of low mass isotopes (particularly deuterium) that are extremely disparate from values observed on the surfaces of stars, on Earth and in the interstellar medium (Schwarzschild 1958). In order to obtain a PP reaction rate slow enough to provide observed luminosity throughout a star's life with a fixed amount of hydrogen, a 10^{-17} core deuterium/hydrogen ratio is calculated; $\sim 10^{-12}$ the $10^{-4} - 10^{-5}$ observed on Earth and in the sky (Clayton 1968). To account for the discrepancy, cosmic ray spallation is suggested to produce the observed deuterium. However, that mechanism is contradicted by ratios of other low mass isotopes (Fowler et al. 1962a).

SAM: With continuing accretion driven fusion, deuterium escapes the fusion region to produce observed D/P ratios.

${}^7\text{Li}$ problem

SSM: The ${}^7\text{Li}$ observed in atmospheric spectra of many main sequence stars including our Sun is ascribed to production by cosmic ray spallation. However, the absence of another stable isotope, ${}^6\text{Li}$, that should also be created by spallation is referred to as 'the lithium problem' (Böhm-Vitense 1992). Fowler, Greenstein and Hoyle (1962a) illustrate the complex theories required to explain low mass isotopic abundances. Common also in nova spectra (Starrfield et al. 1978) as is the ${}^7\text{Be}$ gamma ray line (Leising 1990), inventive models such as slow precursor PP fusion (Starrfield 1989) are created to account for their presence.

SAM: The daughter of ${}^7\text{Be}$ decay (Fig. 2), the presence of ${}^7\text{Li}$ in the Sun's atmosphere and those of most main sequence stars is a consequence of accretion driven outer zone fusion. Its presence (plus other PP indicators) in novae evidence the PP reaction taking place explosively.

0.5 MeV gamma ray sky background - Satellite borne telescopes observe a sky background of these photons that likely originate from positron-electron annihilation. They are also observed in solar flares (Ramaty & Lingenfelter 1979).

SSM: No satisfactory explanation for the ubiquity exists.

SAM: Widespread accretion driven PP outer zone reactions (Fig. 2) are the likely positron source.

Dredge-up

SSM: To explain observed fusion products in population II red giants and associated nebulae, a process called 'dredge-up' is hypothesized wherein circulation extending from the core to the surface raises them to be ejected in the stellar wind. How hydrogen is retained in the core in the presence of such a circulation is ignored.

SAM: Fusion products in stellar atmospheres are appropriate.

H-R main sequence

SSM: SSM offers no explanation for the shape nor position of the H-R main sequence curve. Hypothesized stellar evolution paths follow complex paths on the color luminosity plot, requiring several figures with unobservable path kinks to show how a single mass star ages.

SAM: The subject of a future paper, the main sequence is the continuing accretion stellar evolution path. A star begins as a dim IR source fusing accreted deuterium to helium. The lower inflection on the main sequence occurs when a star's mass ($\sim 0.4M_{\odot}$) and size ($\sim 0.6R_{\odot}$) achieve values where the infalling magnetic pinched plasma arrives with a velocity of 500 km/s, initiating outer zone PP fusion. The upper inflection occurs when the mass reaches $\sim 6.5M_{\odot}$ and size $\sim 4R_{\odot}$, resulting in an influx velocity of ~ 800 km/s. This will begin the triple alpha reaction, fusing helium to carbon (Fowler et al. 1962b). Spectra for stars above this inflection show the presence of strong carbon lines (Underhill 1955; Wilson 1955). Departure from the main sequence is the consequence of outside (other stars) gravitational interaction.

6. Concluding

The tally of SSM faults, flaws and inexplicable phenomena compared with the observation based continuing accretion model (SAM) could be expanded many fold; but the point has been made. In Sect. 4 we presented experimental proof, with a large signal to noise ratio, obtained by two independent teams, that for the Sun, a typical star, the hypothesized nebula collapse – standard stellar (solar) model cannot be reconciled with the short half-life ${}^7\text{Be}$ found in the Earth's exosphere. The only explanation consistent with physics is: the beryllium was transported by the solar wind from the outer zone of the Sun where it was produced by fusion.

Recognition of a near invisible baryonic cluster population (cosmoids), the gravitationally noted 'dark matter,' for which we have selected but a few examples from a plethora of observations, allows us with no assumptions, to answer numerous riddles posed by recent measurements. The reader can undoubtedly find other examples where this population impacts his/her discipline. In explaining observation, compare, for example, continuing accretion stellar evolution along the main sequence of the H-R diagram as opposed to the tortuous SSM paths requiring several plots for even a single mass star. Hypothesized tumultuous kinks in the path are unobservable but accepted on faith (e.g., the helium flash). Counterintuitive also is the SSM thesis that the youngest stars are the largest and (now measured) the most volatile. Continuing accretion driven outer zone fusion permits understanding of stellar luminosity/wind variation and the ubiquity of stellar (planet containing) disks that host future stars. The relative simplicity of SAM must appeal to any who can see beyond the psychological barrier erected by inculcated theory.

Committed to SSM, unwilling to relinquish belief in nebula collapse, core fusion, etc., supporters cite the myriad of explanations underlying that body of hypotheses. They argue that stars would collapse without the heat (radiation pressure) provided by core fusion. Chandrasekhar (1939) found no difficulty in positing stellar structure

before the invention of core fusion. He noted that the interior would be at several million kelvin if *it behaved as a perfect gas*. We use italics to emphasize the assumption. Surrounding a star with a fusion shell satisfies the need for internal heat while the density gradient directs radiation pressure outward.

As all stellar measurements with the singular exception of neutrinos are surface (or above) observations, interior structure is assumed. The neutrino ‘problems’ have exposed the flaw, with numerous (ad hoc physics) assumptions attempting to bridge discrepancies. Outer zone fusion shows all existent neutrino experiments yield consistent results (Dubin & Soberman 1996); contradicting Bahcall’s (1996) conclusion “...it does not appear possible to reconcile the four operating experiments with any modification of stellar physics.”

Structures may stand, however, long after their foundations have deteriorated. Thus, after providing proof that SSM is flawed and fails by comparison to continuing accretion, acceptance may continue to be elusive. Other than those cited above there are numerous tests that can distinguish between SSM and SAM. E.g., ^7Be should be found in the solar wind perhaps by instruments already operating beyond the terrestrial magnetosphere; cluster fusion experiments (Beuhler et al. 1989) with ^1H and ^3He in the target should yield the 0.5 MeV gamma ray signature of positron annihilation showing the PP reaction occurring explosively. The astute reader will undoubtedly be able to suggest more. We challenge critics to find a measurement (as opposed to a SSM derived explanation for same) that is in conflict with the foregoing.

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